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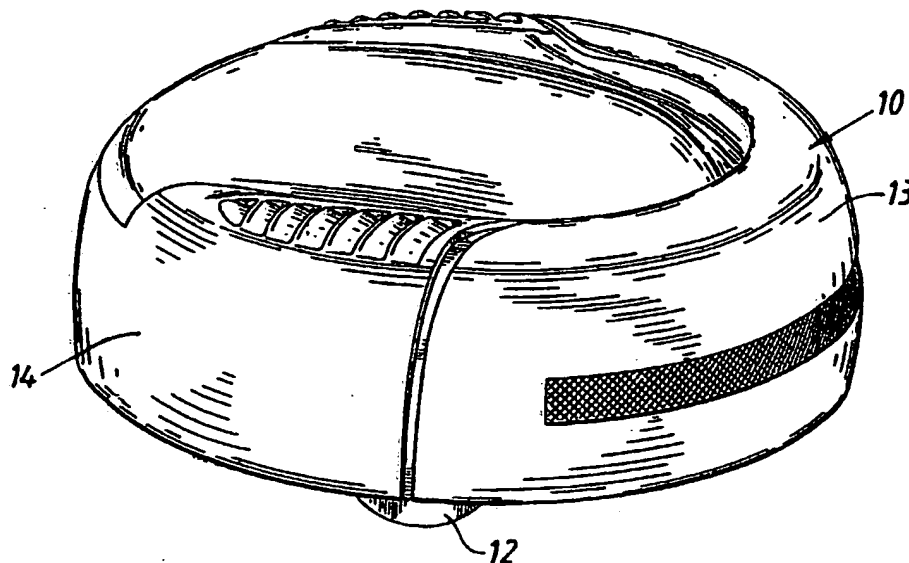
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(54) Title: OBSTACLE SENSING SYSTEM FOR AN AUTONOMOUS CLEANING APPARATUS



(57) Abstract: A device for an autonomous cleaning apparatus such as a robot vacuum cleaner. The apparatus has a chassis with a housing including a front bumper part and at least two drive wheels (12) or the like. The housing also includes an electric guidance and control system and an obstacle sensing system including the front bumper part (13). The front bumper part is movably arranged with respect to the chassis and the movement between the chassis and the front bumper part is sensed and causes a control signal to be transmitted to the guidance and control system when the front bumper part encounters an obstacle or obstruction. The guidance and control system can then maneuver the robot vacuum cleaner around the obstacle or obstruction.

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## OBSTACLE SENSING SYSTEM FOR AN AUTONOMOUS CLEANING APPARATUS

This invention relates to a device for an autonomous cleaning apparatus such as a robot vacuum cleaner comprising a chassis with a housing including a front and a rear part and at least two drive wheels or the like. The housing also includes an electric guidance and control system and an obstacle sensing system having said front part, which acts as a "bumper", and which is movably arranged with respect to the chassis. The movement between the chassis and the front part is sensed and causes a control signal to propagate to the robot vacuum cleaner's guidance and control system.

Vacuum cleaners of the type mentioned above are previously known, see WO 95/26512, wherein the movable part (i.e., the bumper) is arranged at the chassis, which is a part of the sensing system, and which moves rearwards with respect to the chassis when the vacuum cleaner strikes an obstacle, thereby acting on a micro-switch. A disadvantage of the schematically shown arrangement in this publication is that the movement is not particularly distinct, but instead requires that rather large friction forces be created at the slide surfaces between the cooperating means of the chassis and the movable part. These frictional forces hinder the movement of the part and can lead to less sensitivity on the part of the device.

The invention provides a support for the movable part (i.e., a bumper), the support being designed such that the frictional forces are minimized, making the movable part easy to react and decreasing the lengths of movement that are necessary to act on a switching means.

FIGURE 1 is a perspective view of an autonomous vacuum cleaner utilizing the sensing system;

FIGURE 2 is a perspective view of a movable front part of the sensing system; and

FIGURE 3 is a vertical section through the front part of the vacuum cleaner showing an embodiment of the sensing system.

An embodiment of the invention will now be described with reference to the accompanying drawings.

The autonomous robot vacuum cleaner is shown in Fig. 1, where the device would move to the right when moving in a forward direction. The robot vacuum cleaner comprises a chassis with a housing 10 and a bottom plate 11. The vacuum

cleaner is guided and driven by means of two wheels 12 which are typically individually driven and arranged at each side of the housing. The housing will typically enclose a power source (such as a battery or set of batteries). A pair of electric motors is typically chosen to drive the wheels with each motor driving a different wheel, for example. Alternatively, a single motor might drive both drive wheels. The drive motor(s), or an additional dedicated motor, is used to drive a vacuum fan unit and a brush roll arranged in a nozzle directed towards the floor surface, to provide a vacuum and sweeping function. The nozzle is connected to the vacuum source via a filter arrangement (for example, a dust bag or filter, or some other type of separation system like a cyclone separator). The housing also encloses an electrical means for operating the vacuum cleaner, the electrical means including an electrical guidance and control system (perhaps utilizing a controller or microprocessor for computation functionality) and an obstacle and/or obstruction sensing system for detecting and avoiding obstacles and obstructions.

In one embodiment, the housing 10 comprises a front part 13 and a rear part 14. The front part 13 is movably arranged with respect to the bottom plate 11, whereas the rear part 14 is typically fixed to the bottom plate. The front part is curved in two directions (such as in both a vertical and a horizontal direction), and the front part is designed to act as a bumper with the ability to detect obstacles and obstructions in the path of the robot vacuum cleaner by bumping into them, whereby the robot vacuum cleaner can detect the obstacle and/or obstruction and maneuver around it. The front part incorporates the cylindrical shape of the robot vacuum cleaner such that the vacuum cleaner has a uniform, mostly continuous, pleasing shape. The rear part 14 has at its front a support part 15 having several supporting devices, such as hooks 16, for example, placed along a horizontal axis perpendicular to the movement direction of the vacuum cleaner. These supporting devices support a rocker arm arrangement. The rocker arm arrangement may be designed as a U-shaped yoke 17 having two legs 17a and a straight section 17b connecting the legs. The straight section 17b has a number of slots 17c, the number of which correspond to the number of hooks, and through which the hooks are inserted, such that the yoke 17 is tiltably supported. Each leg 17a is at its lower end provided with a dowel 17d. Each dowel is turnably and/or rotatably supported in a recess in a bracket 18, the bracket being integrated with the front part 13 with the recesses being preferably placed such that the front part 13 is supported at its center of gravity, or close to it. The yoke further is

provided with two spring supports 17e arranged close to each leg at each side of the yoke. The spring supports 17e each support a spring 19 which can, for example, have a coil shaped thread. The springs 19 have extended ends, one end resting against a shoulder 17f at the leg 17a whereas the other end rests against a stop means 20  
5 arranged at the support part 15. The springs 19 are tensioned in such a way that they try to rotate the lower part of the yoke 17 and hence the front part 13 in the forward direction i.e. to the left in Fig. 3.

The front part 13 also supports an activation means 21 connected to a switching means 23 for detecting a motion of the front part. For example, in one  
10 embodiment, the activation means includes two arms 21 (which can be designed as plates, for example) with openings that are engaged with a sliding surface 22 at the front part of the bottom plate 11, with each opening being provided with a front and a rear limiting edge 21a and 21b. For this embodiment, the switching means can be implemented by using micro-switches 23, for example, with the activation means  
15 connected to the switching means by providing that each opening surround a micro-switch, wherein an operating knob 23a of the micro-switch normally is depressed by means of the rear limiting edge 21b. The micro-switches 23 can be arranged on a circuit board 23 which is supported by means of a plate 25 connected to the bottom  
20 plate. The two micro-switches are connected to the electric circuit of the vacuum cleaner. The stop means in its normal position keeps the operating knob of the micro-switch in its depressed position such that small movements of the front part will influence an electrical signal, thereby effecting the electric circuit and providing indications that the front part is encountering obstructions or other objects. It is within the scope of the invention, if desired, to replace the micro-switches by other types of  
25 previously known position detectors.

The robot vacuum cleaner operates in the following manner: When the vacuum cleaner has been activated and placed on a surface, such as a floor surface to be cleaned and/or vacuumed, it is guided by means of the electric circuit and/or a control circuit or microprocessor. This electric circuit also includes means for sensing  
30 the surroundings and/or for detecting the position in the room without physically touching the objects. The guiding and driving of the robot vacuum cleaner is accomplished by means of the drive wheels 12 and the circular shape of the vacuum cleaner making it possible for the robot vacuum cleaner to be turned through 180° while minimizing any risk of it being hindered and/or stuck in a trapped position.

When the movable front part 13 of the vacuum cleaner engages an obstacle or obstruction, it will be moved rearwards with respect to the bottom plate 11 and the rear part 14, while at the same time the movable front part 13 is guided in its movement by abutting the rear part at several points. This means that the yoke 17 will  
5 tilt anticlockwise as shown in Fig. 3 about the support points, i.e. the hooks 16 against the action of the spring 19 at the same time as the arms 21 will move rearwards with respect to the bottom plate 11 and the circuit board 23. This movement activates one or both of the micro-switches 46 causing a signal to be transmitted to the electric circuit shutting off the drive motors 36, after which the controller or microprocessor  
10 causes the vacuum cleaner to turn such that it is released from the obstacle or obstruction and can maneuver around it, whereby the movable front part 13 returns to its original position by means of the springs 19 when no longer in contact with the obstruction or object.

The straight section 17 is preferably designed such that it is rather flexible in  
15 the side direction with respect to torsion forces, which allows the two legs 17a can work more or less independently from one another. By measuring the time difference between the activations of the two micro-switches, it is possible for the electronic circuit of the guide system to calculate the approximate position of the object with respect to the vacuum cleaner and adapt its driving and guiding movements with  
20 respect to this particular obstacle or obstruction, improving the ability of the robot vacuum cleaner to maneuver around them.

By means of the design described above an efficient obstacle sensing system is achieved which has a high degree of sensitivity for influences from outer forces and which gives a distinct reaction when contacting an object. This depends on that the  
25 support system of the front part is designed such that the friction influences are minimised at the same time as the micro-switches are placed such that the operating knobs normally are in their depressed position which gives an immediate reaction when an obstacle is hit.

## Claims:

1. A device for an autonomous cleaning apparatus such as a vacuum cleaner comprising:
  - 5 at least two drive wheels (12);
  - a chassis with a housing including:
    - a front and a rear part (13,14);
    - an electric guidance and control system; and
    - an obstacle sensing system including the front part (13) which is
    - 10 movably arranged with respect to the chassis, wherein a movement between the chassis and the front part is sensed causing a control signal to be communicated to the guidance and control system; **characterized in** that the obstacle sensing system also including at least one switching means (23), wherein the front part (13) is connected to the at least one switching means via
    - 15 an activation means (21), the switching means being maintained in a normal depressed position by the activation means.
2. The device according to claim 1, **characterized in** that the at least one switching means (23) is a micro-switch, the micro-switch having an operating knob (23a), wherein the normal depressed position is maintained by having the operating knob
- 20 depressed by the activation means (21).
3. The device according to claim 2, **characterized in** that the activation means (21) is an arm extending from the front part (13), the arm having an opening that is provided with a rear limiting surface (21b) that abuts the operating knob (23a) of the micro-switch.
- 25 4. The device according to claim 2 or 3, **characterized in** that the micro-switch is placed on a circuit board (24) supported by the chassis.
5. The device according to any of the preceding claims, **characterized in** that the front part (13) is turnably supported at the chassis by means of a rocker arm arrangement (17).
- 30 6. The device according to claim 5, **characterized in** that the rocker arm arrangement (17) comprises a first rocker arm (17a) placed on one side of a

- central middle line of the device and a second rocker arm (17a) placed on another side of the central middle line of the device, the first and second rocker arms each having upper and lower support points, one of the upper and lower support points turnably connecting the chassis with the corresponding rocker arm whereas the other of the upper and lower support points turnably connecting the corresponding rocker arm with the front part.
7. The device according to claim 6, **characterized in** that the rocker arm arrangement is under the influence of at least one spring (19) for pressing the front part (13) in the forward direction with respect to the chassis.
8. The device according to claim 7, **characterized in** that a spring (19) is arranged in association with each rocker arm (17a).
9. The device according to any of claims 5-8, **characterized in** that the rocker arms (17a) are legs of a U-shaped yoke, the legs being connected to one another by means of a horizontal section (17b) arranged substantially perpendicular to the direction of movement of the device.
10. The device according to claim 9, **characterized in** that the horizontal section is provided with several openings (17a) which are inserted into hook shaped means (16) arranged at the chassis.
11. The device according to any of claims 5-10, **characterized in** that the front part (13) is supported by the rocker arm (17) arrangement at or about the center of gravity point of the front part (13).
12. An autonomous cleaning apparatus comprising:
- at least two drive wheels (12);
  - a chassis with a housing including:
    - a front and a rear part (13,14);
    - an electric guidance and control system; and
    - an obstacle sensing system comprising:
      - the front part (13) which is movably arranged with respect to the chassis, wherein a movement between the chassis and the front part is sensed, causing a control signal to be communicated to the guidance

and control system;

**characterized in** that the front part is turnably supported at the chassis by means of a rocker arm (17) arrangement, wherein the rocker arm arrangement includes:

5           a first rocker arm (17a) placed on one side of a central middle line of the device; and

10           a second rocker arm (17a) placed on another side of the central middle line of the device, wherein the first and second rocker arms each have upper and lower support points, one of the upper and lower support points turnably connecting the chassis with the corresponding rocker arm, whereas the other of the upper and lower support points turnably connecting the corresponding rocker arm with the front part;



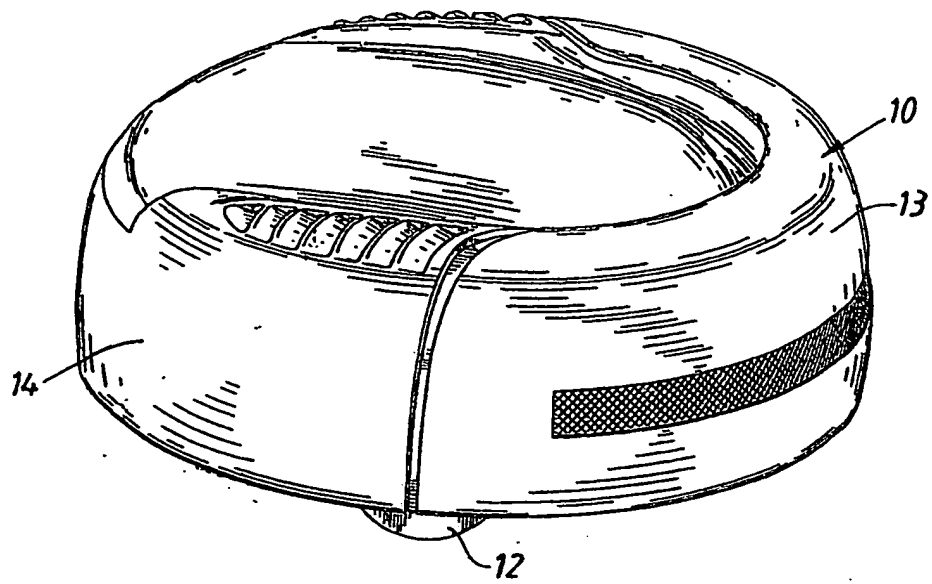


FIG. 1

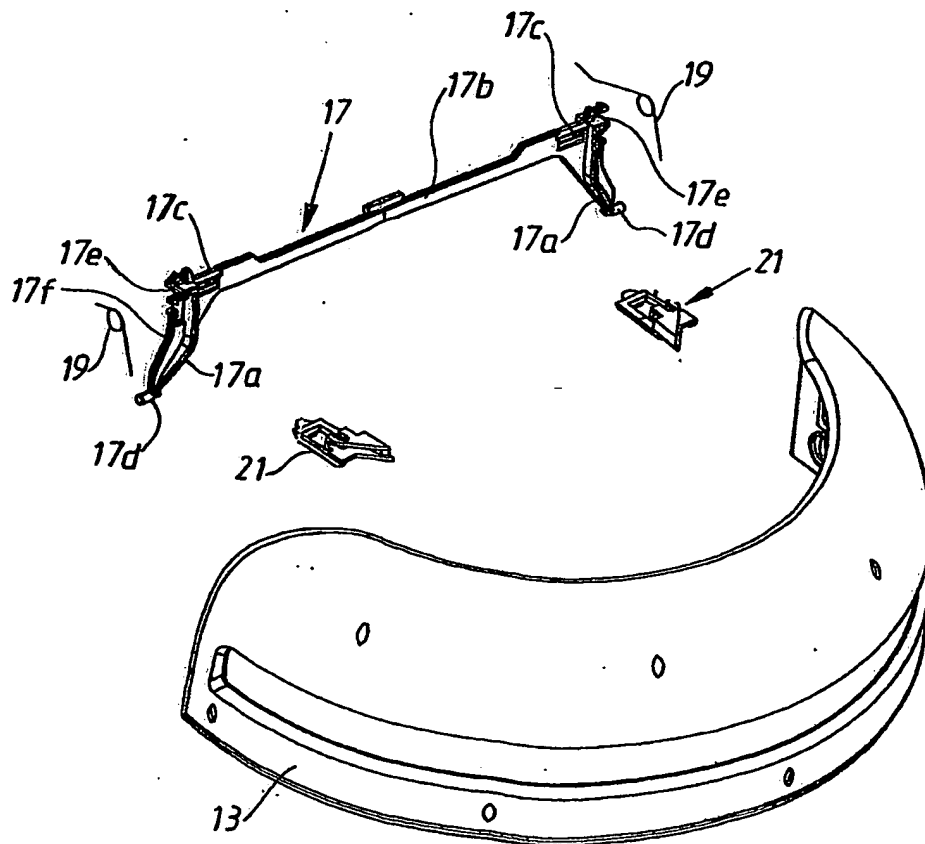


FIG. 2

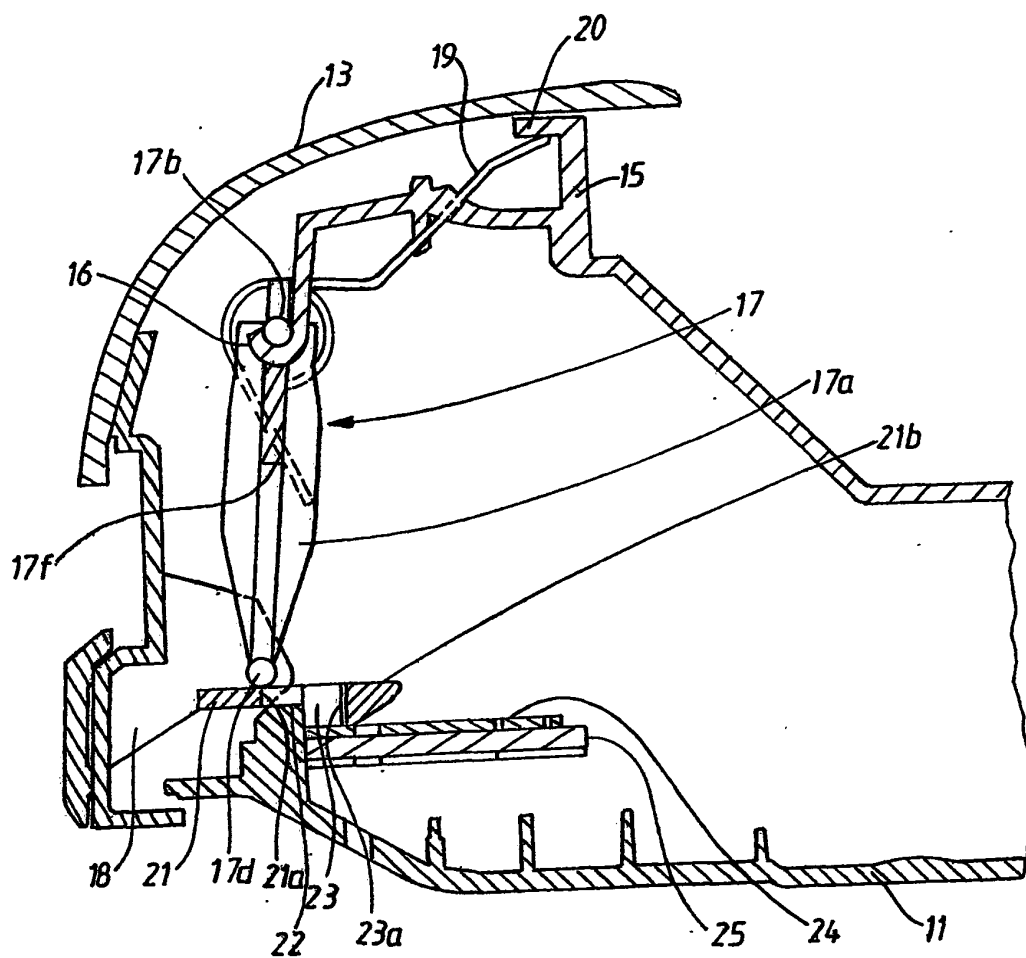


FIG. 3

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 02/00342

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A47L 9/00, A47L 11/40

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: A47L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5935179 A (M. KLEINER ET AL), 10 August 1999 (10.08.99), detail 16 --	1-12
A	WO 9526512 A1 (AKTIEBOLAGET ELECTROLUX), 5 October 1995 (05.10.95), figure 3, detail 21 --	1-12
A	Patent Abstracts of Japan, abstract of JP 9-319435 A (MINOLTA CO LTD), 12 December 1997 (12.12.97), details 103, 202 --	1-12
A	US 5214822 A (H. SAKURAI ET AL), 1 June 1993 (01.06.93), details 45, 710, 900 -----	1-12

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